Resumen en Español

Campylobacter Infection and Exposures Among Employees at a Poultry Processing Plant — Virginia

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NIOSH *National Institute for Occupational Safety and Health*

The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

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Abbreviations

CFR	Code of Federal Regulations
CI	Confidence interval
EIA	Enzyme immunoassay
FSIS	Food Safety and Inspection Service
GBS	Guillain-Barré syndrome
HACCP	Hazard analysis and critical control points
HHE	Health hazard evaluation
HVAC	Heating, ventilating, and air-conditioning
mL	Milliliter
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PCR	Polymerase chain reaction
PPE	Personal protective equipment
ppm	Parts per million
RR	Relative risk
USDA	U.S. Department of Agriculture

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from management representatives at a poultry processing plant in Virginia. The request concerned the occurrence of *Campylobacter* infections, which can cause diarrheal illness among employees, especially among live hang area employees.

What NIOSH Did

- We visited the plant in May 2011.
- We observed work practices and interviewed 88 employees.
- We reviewed records from the medical office at the plant.
- We evaluated the ventilation in the live hang area.
- We reviewed the water testing program for chlorine.
- We reviewed the chicken carcass testing program for *Campylobacter*.
- We reviewed the records from the cases of *Campylobacter* infection at the plant.

What NIOSH Found

- We found 29 confirmed cases of *Campylobacter* infection among plant employees over 3½ years.
- Most infected employees worked at the plant for less than a month, worked in the receiving/live hang area, and lived at a state-operated diversion center.
- Many employees reported that they had had diarrhea at some time between January and May 2011. Many did not report their illness to the plant.
- Supply air vents in the live hang area were above the heads of employees. The vents directed air down toward the conveyer belt. This may spread contamination.
- Chlorine levels in the chillers that were recorded by the plant were within USDA requirements.
- Employees had to buy some personal protective equipment (PPE).

What Managers Can Do

- Reduce *Campylobacter* contamination in the plant through improved sanitation and other engineering controls. The live hang area should be the initial focus of these efforts.
- Consider redirecting airflow from the ducts in the live hang area away from live chickens. This change should reduce the potential for spreading contamination.
- Improve employee training on hand washing and PPE use.
- Give employees all of the PPE that their jobs require free of charge.

Highlights of the NIOSH Health Hazard Evaluation (continued)

What Employees Can Do

- Wash your hands before and after work, breaks, smoking, contact with chickens and chicken products, and PPE use.
- Wear PPE as directed.
- Inform the medical office in the plant if you have diarrhea.

Summary

NIOSH investigators examined the occurrence of *Campylobacter* infection among employees at a poultry processing plant. We found 29 cases of laboratory-confirmed *Campylobacter* infection among employees during a 3½-year period. On the basis of our interviews with employees, gastrointestinal illness appeared to be common, yet underreported.

In February 2011, we received an HHE request from employer representatives at a poultry processing plant in Virginia. The request concerned the occurrence of *Campylobacter* infections among employees, especially among those working in the live hang area of the plant.

During our visit to the plant in May 2011, we reviewed work procedures and training materials for employees and records from the plant medical office. We learned more about the plant's ventilation system and its environmental sampling program for chlorine and *Campylobacter*. We also interviewed 88 employees and observed work practices. We reviewed the confirmed cases of *Campylobacter* infection among plant employees.

We found 29 cases of laboratory-confirmed *Campylobacter* infection among plant employees during a 3½-year period. Most of these employees worked in the live hang area, worked at the plant for less than a month before illness onset, and were residents of a diversion center (a residential program operated by the Virginia Department of Corrections). We also found that approximately 15% of more than 3,000 encounters at the plant's medical office from January 2010 through September 2011 were related to gastrointestinal symptoms. In addition, almost one third of the 88 employees interviewed reported being ill with gastrointestinal symptoms in a 5-month period before the interview, and fewer than half of these employees reported their illness to the plant. Therefore, gastrointestinal illness was quite common and appeared to be underreported. The absence of paid sick leave may have played a role in this underreporting. Of all employees, receiving/live hang area employees appeared to be particularly affected by gastrointestinal illness. We also observed inconsistent hand hygiene and PPE use in the live hang area; these observations agreed with the self-reported practices of interviewed employees. Employees also reported having to pay for some PPE.

We observed that the ventilation system had 20 supply air vents above the heads of the live hang area employees. These vents directed air at a downward angle toward the conveyor where the chickens were located before they were shackled. This could have led to the potential to aerosolize or spread potential contamination from the birds to the live hang area employees. Chlorine levels in the water immersion chillers, as reported on the company logs, were within the USDA requirement of 20–50 ppm.

Summary (continued)

A health hazard from *Campylobacter* infection exists in this plant. Efforts to reduce *Campylobacter* contamination in the plant, particularly in the receiving/live hang area, should be strengthened. Such efforts should include improved sanitation and the use of other engineering controls, including redirecting airflow from the ducts in the live hang area away from the live birds. Training and compliance with hand hygiene and PPE use should also be improved.

Keywords: NAICS 311615 (Poultry Processing), *Campylobacter*, campylobacteriosis, infection, poultry processing, diarrhea, gastrointestinal, Hispanic workforce

In February 2011, NIOSH received an HHE request from management representatives at a poultry processing plant in Virginia. The request, suggested by the Virginia Department of Health, concerned the occurrence of *Campylobacter* infections among employees, especially among those working in the live hang area of the plant.

In May 2011, we visited the plant and observed work processes, work practices, and workplace conditions. We interviewed plant employees, reviewed the encounter records from the plant's medical office, and reviewed work procedures and health and safety-related policies and training materials. We learned more about the plant's ventilation system and environmental sampling program for *Campylobacter* and chlorine and measured air flow in the live hang area. We also reviewed medical and work records of current and former plant employees diagnosed with confirmed *Campylobacter* infection.

Poultry Processing Operations

At the time of our visit, the plant in Virginia was one of several plants operated by the poultry processing company across the country. The plant processed approximately 1.6 million pounds of chicken, or an estimated 300,000–350,000 birds, per day. Chickens were transported in crates to the plant after a growth period on the farm. The plant comprised two processing areas. In "first processing," birds were unloaded, shackled, stunned, killed, scalded, defeathered, eviscerated, and chilled in large water immersion chillers. In "second processing," the carcasses were rehung, washed, cooled, and packaged. Further processing, including breast deboning, was also performed at the plant. A new live hang area opened in January 2011 and was in operation when we visited the plant. However, the new break room and locker room adjacent to this area were not yet operational.

The plant employed approximately 1,000 individuals who typically worked 8-hour shifts. Employees were not unionized at this plant. Approximately 450 employees worked on the first shift, 375 on the second shift, and 175 on the third shift. Employees working the first and second shifts processed the chicken, while employees working the third shift performed duties related to shipping, maintenance, and sanitation. The areas employing the largest numbers of employees were the breast debone and second and

further processing departments. The receiving area, which also contained the live hang area, employed 29–31 individuals per shift, and this typically included 22–24 live hangers and 7 employees who worked either in the receiving yard or kill rooms.

At the time of our evaluation, the poultry processing plant had an agreement with the Virginia Department of Corrections to provide an opportunity for residents of two local diversion centers to work and earn salaries for part of their sentence. These diversion centers offered a 24-week residential program for nonviolent offenders sentenced in Virginia circuit courts. Diversion Center A housed approximately 108 inmates, while Diversion Center B housed approximately 80 inmates. A typical work assignment lasted 16 weeks, and diversion center residents paid room and board, transportation, and a portion of their medical insurance. Diversion center residents were assigned to this and other poultry processing plants, manufacturing companies, fast food establishments, diversion center farms, or grounds keeping. The plant employed approximately 24–35 residents from the diversion centers at any given time.

Background on *Campylobacter* Infection

Campylobacter infection, or campylobacteriosis, is an infectious disease caused by bacteria of the genus, *Campylobacter*. *Campylobacter* is the one of the most common bacterial causes of gastrointestinal infection in the United States. It is most often associated with sporadic cases of illness rather than outbreaks. In 2010, the Foodborne Diseases Active Surveillance Network estimated about 14 cases are diagnosed each year for each 100,000 persons in the United States [CDC 2011b]. Campylobacteriosis is estimated to affect 2.4 million persons each year [CDC 2011b]. Most human *Campylobacter* infections are caused by *Campylobacter jejuni* [Friedman et al. 2000].

Campylobacter transmission typically occurs through consumption of undercooked poultry and/or the handling of raw poultry [Skirrow 1982; Hopkins et al. 1984; Oosterom et al. 1984; Tauxe et al. 1985; Harris et al. 1986; Kapperud et al. 1992; Blaser 1997; Altekruse et al. 1999]. Accidental ingestion of 1 drop of raw chicken juice, which can contain as few as 500 organisms can constitute an infectious dose [Friedman et al. 2000; Newell and Wagenaar 2000]. Cases and outbreaks have also been traced to raw milk, contaminated water, and contact with pets and farm animals [Korlath et al. 1985; Kapperud et al. 1992; Altekruse et al. 1999].

Most people who become ill with *Campylobacter* infection get diarrhea, cramping, abdominal pain, and fever within 2 to 5 days after exposure to the organism. The diarrhea may be bloody and can be accompanied by nausea and vomiting. The illness typically lasts 1 week, and most cases do not require the use of antibiotics. Some infected persons have no symptoms. In persons with compromised immune systems, *Campylobacter* occasionally spreads to the bloodstream and can cause a life-threatening infection.

In rare instances, some infected persons can develop GBS after having an infection with *Campylobacter jejuni*. GBS is a rare disorder in which a person's own immune system damages the nerve cells, causing muscle weakness and sometimes paralysis. GBS can cause symptoms that last for a few weeks or several months. Most people recover fully from GBS, but some have permanent nerve damage. In the United States, an estimated 3,000 to 6,000 people develop GBS each year [CDC 2011a].

Campylobacter is a commensal organism of poultry, which means it typically colonizes the gastrointestinal tract of these animals without causing disease. In poultry, *Campylobacter* can be found on the skin, feathers, and gastrointestinal tract. Colonization of chickens in high-density houses occurs rapidly, and prevalence can reach 90%–100% in commercial broiler flocks [McCrea et al. 2006a; McCrea et al. 2006b]. Because most *Campylobacter* infections are attributed to poultry and poultry products, reducing levels of *Campylobacter* contamination associated with raw poultry is important.

In July 1996, the USDA FSIS implemented the Pathogen Reduction HACCP System final rule [USDA 1996]. HACCP is a management system that addresses food safety through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement, and handling to manufacturing, distribution, and consumption of the finished product. The process includes microbial testing, pathogen reduction performance standards, and sanitation standard operating procedures, which significantly reduce contamination of meat and poultry with harmful bacteria and reduce the risk of foodborne illness. Currently, FSIS does not have a performance standard for *Campylobacter*, but establishments can choose to include *Campylobacter* in their HACCP analysis. If the establishment identifies *Campylobacter* as reasonably likely to occur, or if *Campylobacter* appears to be an emerging problem in their

process, FSIS expects the establishment to implement controls to address this microbial food safety hazard.

Virginia Department of Health Investigation

In March 2008, the Virginia Department of Health was notified of multiple cases of *Campylobacter* infection among persons working the same shift at the plant who were also residents of the two diversion centers. Investigators conducted a retrospective cohort study, environmental inspections of the plant and diversion centers, and laboratory analysis of stool specimens. A case of *Campylobacter* infection was defined as illness in any English-speaking second shift employee at the plant who had either laboratory-confirmed *Campylobacter* culture or positive EIA result or who reported onset of diarrhea and one or more of the following symptoms: abdominal cramps, fever, nausea, and vomiting between January 1, 2008, and April 21, 2008. Investigators interviewed 38 English-speaking, second shift employees and found that 18 (47%) met the case definition for *Campylobacter* infection. Fifteen (83%) of these ill individuals were residents of a diversion center. Because Spanish interpreters were not readily available at the time of that investigation, the cohort was limited to English-speaking employees only.

Investigators found that residents of the diversion centers were more likely to have *Campylobacter* infection compared to nonresidents (P = 0.04). They also found that wearing PPE, such as a dust mask, safety glasses, gloves, coveralls, aprons, smock, and rain suit was not significantly protective against disease. However, individuals who reported washing their hands after the work break (RR = 0.4, 95% CI 0.3–0.7), after smoking (RR = 0.5, 95% CI 0.3–0.8), and before eating (RR = 0.5, 95% CI 0.3–0.7) had significantly lower risk of infection compared to those who did not report these behaviors. The investigation was not able to determine why residents of diversion centers were more likely to become infected with *Campylobacter*.

Recommendations from the investigation included improving PPE availability, training and enforcement of proper hand washing and PPE use, and addressing the plant sick leave policy to ensure employees do not work while ill. Despite these recommendations, subsequent cases of *Campylobacter* infection among employees were identified, prompting the HHE request by plant management.

The purposes of our evaluation were to (1) estimate the incidence of acute gastrointestinal illness among current plant employees, (2) investigate the incidence of confirmed *Campylobacter* infection among plant employees from 2009–2011, and (3) assess the controls in place to reduce *Campylobacter* contamination.

During our visit to the plant on May 9–11, 2011, we observed work processes, work practices, and workplace conditions and spoke with employees about their work practices and health concerns. We discussed the request with the first shift USDA veterinarian, plant managers, and the medical staff on first and second shifts.

Our evaluation included the following methods: (1) a review of work procedures and training materials for employees; (2) a review of the encounter records from the plant medical office; (3) semistructured confidential medical interviews with current employees; (4) observation of the plant's ventilation system and spot ventilation measurements in the live hang area; (5) a review of the water testing program for chlorine and *Campylobacter*; (6) observations of work practices; and (7) a review of the confirmed cases of *Campylobacter* infection among plant employees.

Review of Work Procedures and Training Materials

We reviewed work policies and procedures for the plant and written training materials for new employees.

Review of Encounter Records from the Plant Medical Office

We reviewed the encounter records from the plant's medical office from January 2010–September 2011 both during and after our visit. We categorized an encounter as gastrointestinal illness-related if the employee reported diarrhea, abdominal cramps, nausea, or vomiting without a reason listed, such as nausea related to pregnancy, migraine headaches, or menstrual cramping. We then tabulated all gastrointestinal illness related encounters by month.

Confidential Medical Interviews

During our visit, we held semistructured confidential interviews with employees from the first and second shifts to discuss their work history and history of diarrheal illness. We also asked open-ended questions about other health and workplace concerns. Because of the focus of the HHE request, these employees included all first and second shift employees working in the receiving/live hang area and all first and second shift employees residing at the two diversion centers working on the dates of the visit. We also invited a convenience sample of first and second shift employees working in other areas of the plant. During these interviews, we also educated employees on *Campylobacter* infection and discussed measures employees could take to reduce their risk of *Campylobacter* infection. We held interviews in English and Spanish.

Review of the Plant's Ventilation System

We met with the maintenance manager and walked through the plant and on the rooftop with a maintenance employee to better understand the plant's ventilation system. We also collected air velocity measurements across the face of some of the supply air diffusers in the live hang area and observed the direction of the air flow from these supply vents. Air velocity was measured at approximately 4-inch intervals across the face of the supply air vents with a TSI VelociCalc® Plus air velocity meter, model 8386A (TSI, Inc., Shoreview, Minnesota).

Review of Environmental Sampling Programs

We met with the HACCP coordinator and laboratory technician to discuss the plant's environmental sampling program and obtained the environmental sampling records for the presence of *Campylobacter* on carcasses after rehang in second processing, and chlorine testing in the immersion water chillers.

Observation of Work Practices

During our visit to the plant, we observed work practices among employees in all areas of the plant. We specifically observed employees' adherence to hand hygiene, PPE use, and PPE removal policies.

Review of Confirmed *Campylobacter* Infection Cases

We obtained lists of individuals diagnosed with confirmed *Campylobacter* infection while employed at the plant between January 2008 and May 2011 from the Virginia Department of Health and the diversion centers. A case was defined as an individual employed at the plant with laboratory-confirmed *Campylobacter* infection by culture or EIA. We then reviewed records of these cases from the Virginia Department of Health, the Virginia Department of Corrections, and local medical providers and obtained additional work history information on these individuals from the plant.

Review of Work Procedures and Training Materials

In the plant's "Take Home Policies and Procedures" manual, employees were instructed to wash their hands when reporting to work, after breaks, after smoking or eating, and after using restroom facilities. All employees were required to wear a hair net, safety glasses, ear plugs, and when applicable, beard nets, when on the plant floor. Additional required and recommended PPE by select areas in the plant are shown in Table 1.

Table 1. Additional required and recommended PPE for employees by select areas in the plant

Area in plant/Job title	Additional required PPE	Recommended/Optional PPE
Receiving/live hanger	Steel toe boots Cotton gloves Rubber gloves Smock	Apron Face shield Disposable dust mask*† Coveralls Goggles
Receiving/backup killer	Boots with good tread Rubber gloves Steel gloves Arm guards Smock Face shield	Plastic apron Rain suit Disposable dust mask†
Evisceration/liver/gizzard inspector‡	Boots with good tread Smock	None
Evisceration/drawer and venter	Protective footwear with good tread Sleeves worn past elbows Smock	Rubber gloves Plastic sleeves
Dapec/rehanger	Boots with good tread Sleeves worn past elbows Smock Apron	Rubber gloves Glove liners Plastic sleeves
Breast debone/shoulder cutter	Protective footwear with good tread Sleeves worn past elbows Smock Rubber gloves Blaze glove Apron	Glove liners Plastic sleeves

*Disposable dust masks were previously required per plant policy in 2008.
† Though disposable dust masks were specified in the plant's written policies, during our visit, we observed that the PPE supply room stocked N95 filtering facepiece respirators.
‡ Liver/gizzard inspectors in the evisceration area were specifically instructed not to wear gloves because of safety concerns related to glove use.

According to the plant's written policy, on hire, employees were issued an initial stock of PPE at no charge, which included earplugs, safety glasses, a hair net, a beard net, green rubber gloves, cotton liner gloves, plastic sleeves, and a plastic apron. Employees were also provided with a smock, which must be turned in every day after work in exchange for a token. The employees then must bring in the token the following day to receive a clean smock. Employees may exchange their smock for a new one during the work day if soiled. Employees were not allowed to wear smocks into the bathroom, into the break room, or outside. Employees working in the receiving/live hang or first processing areas were required to change their smocks if they needed to go into second processing or the breast deboning areas.

At the time of our visit, a licensed practical nurse was present at the plant during the first and second shifts to evaluate medical issues that arose in employees. The plant did not provide paid sick leave for nonmanagement employees, but used a point system. Employees accrued two points for a full day absence or arriving late or leaving more than 4 hours early, and they accrued one point for arriving late or leaving less than 4 hours early. However, properly documented absences of more than one day for the same illness resulted in only two points. In contrast, undocumented absences of more than one day accrued points for each day. Employees were terminated if they accumulated 20 points. Any new employee who accrued six points in the first 30 days of employment was terminated regardless of the reason. Employees could reduce their point total by two points for each 30 consecutive days of employment with no accrued points.

Review of Encounter Records from the Plant Medical Office

In 2010, 1,716 encounters at the plant's medical office were recorded. Of these, 273 (16%) were related to gastrointestinal symptoms. From January 2011 through September 2011, 1,543 encounters at the plant's medical office were recorded. Of these, 221 (15%) were related to gastrointestinal symptoms. Figure 1 displays the number of gastrointestinal-related visits by month over this time period. Multiple peaks were seen in summer 2010 and winter 2010–2011 and a smaller peak in summer 2011.

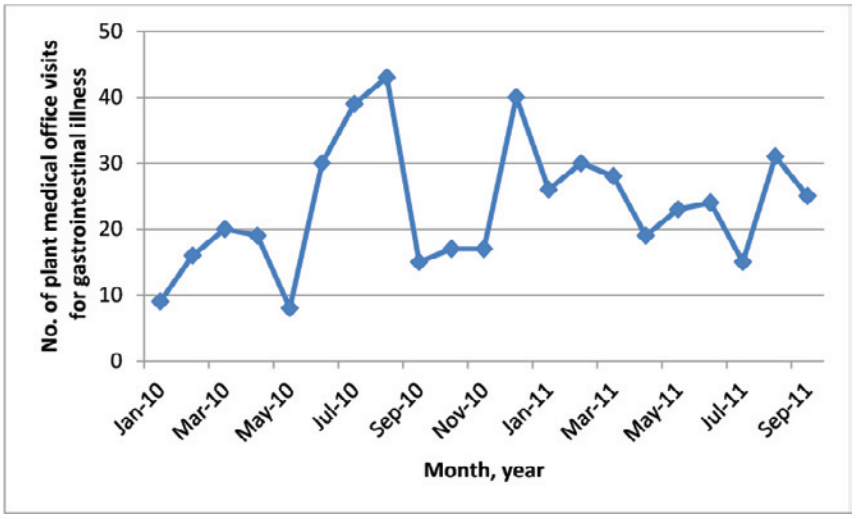


Figure 1. Number of visits related to gastrointestinal illness at the plant's medical office.

Other reasons for visits to the plant's medical office included injury reporting and first aid, musculoskeletal complaints and treatment, and other miscellaneous medical complaints.

Confidential Medical Interviews

Of the 89 invited first and second shift employees, 88 (99%) participated in the interviews. Nine interviews were conducted in Spanish. Five (6%) of the 88 interviewed employees were female; 83 (94%) were male. The median age was 32 with a range of 18–67 years. Of these 88 employees, 31 (35%) were current residents of Diversion Centers A or B, and 5 (6%) had been former residents of these diversion centers.

Work History and Practices

Forty-three (49%) employees worked first shift, and 45 (51%) worked second shift. The median amount of time worked by interviewed employees at the plant was 8 months, with a range of 1 day–39 years. The most common areas where interviewed employees worked were receiving/live hang (64%), rehang (10%), evisceration (8%), and stack-off (5%). The remaining employees worked in breast debone, cut-up, dapec (a type of processing), further processing, paws, packaging, maintenance, and support areas. Of the 31 employees who were current residents of either diversion center, the most common areas worked were receiving/live hang (32%) and rehang (29%). Twenty (23%) employees

reported working at another poultry processing plant prior to this plant, with length of employment ranging from 2 weeks–17 years.

Regarding work practices, 70 (83%) of 88 interviewed employees reported receiving training on possible health effects related to their work upon hire. In addition, 78 (91%) of interviewed employees reported being provided with written policies regarding PPE use, and 84 (97%) reported having education or training about PPE when they started work. Sixty-three (75%) employees reported ever having to pay for any PPE themselves.

Table 2 shows the reported frequency of PPE use at work. Most interviewed employees reported always wearing gloves (89%), rubber boots (72%), full length smock (92%), safety glasses or goggles (91%), and hair covers (95%). In addition, 12 (14%) of 88 interviewed employees reported handling poultry without wearing gloves in the 2 weeks before their interview or the 2 weeks before illness onset.

Table 2. Frequency of PPE use reported by interviewed employees while at work

	No. (%) Employees, n= 74–86		
PPE component	Always	Sometimes	Never
Gloves	76 (89)	5 (6)	4 (5)
Rubber apron	24 (28)	8 (9)	53 (62)
Rubber boots	62 (72)	2 (2)	21 (24)
Full-length smock	81 (94)	2 (2)	3 (3)
Disposable dust mask	23 (27)	7 (8)	54 (64)
Plastic face shield	6 (7)	3 (3)	74 (89)
Safety glasses or goggles	77 (91)	1 (1)	7 (8)
Hair cover	82 (95)	0 (0)	4 (5)

Regarding hand hygiene practices, 73 (87%) of interviewed employees reported always washing their hands before starting work while 78 (92%) reported always washing their hands after completing work. Seventy-two (85%) reported always washing their hands before a break while 66 (79%) reported always washing their hands after a break.

Reports of Gastrointestinal Illness

Twenty-eight (32%) interviewed employees reported being ill with gastrointestinal symptoms in the period from January 1, 2011, to the date of the interviews in May 2011. All 28 of these employees were male and 15 (54%) were residents of a diversion center at the time of the interviews. Eighteen (64%) had started working at the plant after January 1, 2011. Fifteen (65%) of the 23 employees who could recall when symptom onset occurred developed symptoms within the first month of working at the plant. Nineteen (68%) of the 28 ill employees worked in the receiving/live hang area. This represented 34% of the 56 employees who work in that area. The other 9 employees reporting a gastrointestinal illness worked in rehang (n = 3), evisceration (n = 2), deboning (n = 2), and stack-off (n = 2).

The number of illnesses reported by the 28 employees reporting a gastrointestinal illness ranged from 1–6 illnesses. Four (5%) interviewed employees reported being ill with gastrointestinal symptoms at the time of the interview. The median duration of symptoms reported by ill employees was 4 days, with a range of 1–14 days. Table 3 displays the symptoms reported by ill employees.

Table 3. Symptoms reported by interviewed employees who reported being ill with gastrointestinal symptoms since January 2011

Symptom Reported	No. (%) Employees n = 28
Diarrhea	28 (100)
Abdominal cramps	23 (82)
Nausea	19 (68)
Muscle aches	17 (61)
Fever	14 (50)
Headache	14 (50)
Vomiting	13 (46)
Bloody stool	2 (7)

Thirteen (46%) of the 28 employees reported seeing a healthcare provider at the plant for their illness, and 13 (46%) reported seeing a healthcare provider outside of the plant for their illness. Eight (29%) reported that they did not see any healthcare provider for their illness.

Six (21%) employees reported that they provided a stool specimen for laboratory testing, and five (18%) reported a diagnosis of *Campylobacter* infection (four with *Campylobacter jejuni* and one with *Campylobacter coli*). These five diagnoses were confirmed by medical record review. None of the ill employees reported being hospitalized. Nineteen (68%) of the 28 ill employees reported being absent from work as a result of their illness, and this ranged 1–4 days.

Review of the Plant's Ventilation System

At the time of our visit, the plant's ventilation system was designed to move air in the direction opposite the process flow (clean to dirty). This was intended to reduce the risk of airborne cross-contamination with potential pathogens in the finished product, similar to the design recommended for poultry processing plants by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. [ASHRAE 2010]. The scalding area had large exhaust fans that drew air from the second processing area and from the live hang area. Some areas in second processing, including cut up and fast food, recirculated and filtered 100% of the air.

Figure 2. Employees in the live hang area. Supply air from ducts located above the employees' heads is directed toward the conveyor that is holding chickens to be shackled.

The live hang area was renovated in 2010 to provide conditioned outdoor air to its occupants. The HVAC system provided 100% outdoor air in this area. Twenty supply air vents above the heads of the live hangers directed air at a downward angle toward the conveyor where the chickens were kept before they were shackled (see Figure 2). The supply air vents were located on both sides of the conveyor. Face velocity measurements ranged from 423–628 feet per minute across six of the supply vents that were measured. Design criteria were not available for comparison with our measurements. Air moved from the live hang area into the scalding area where it was exhausted from the building.

Review of Environmental Sampling Programs

In 2010, USDA proposed a performance standard to test poultry carcasses for *Campylobacter* contamination [USDA 2010]. The plant randomly tested carcasses for *Campylobacter* immediately after chickens were rehung in the second processing area. A random

Figure 3. Water cooler in the live hang area.

Figure 4. Waste receptacle near a hand washing station. The receptacle required an employee to push back the lid to dispose of waste.

whole carcass was selected from the line and placed in a bag. A sterile buffered peptone water solution (400 mL) was washed over the carcass, collected, and analyzed for *Campylobacter* bacteria using the BAX® System real-time PCR assay. If a positive result was obtained, the test was rerun using additional sample water. If a positive result was detected in the second sample, the result was recorded as positive on the log sheet. The USDA performance standard guidelines allow for up to 8 of 51(16%) 1 mL samples or 27 of 51 (53%) 30 mL samples to be positive for *Campylobacter*. According to plant management, if more than seven occurrences per 51 samples are found, USDA requires changes to the antimicrobial program. The plant also indicated that USDA may begin independent testing for *Campylobacter* in the future. According to the log sheets, approximately 415 samples were collected from December 21, 2010 to April 20, 2011; six carcasses were determined to be *Campylobacter* positive. Nine additional carcasses were positive on the first test, but negative on retest.

Both chiller water tanks were tested for the presence of chlorine 5–6 times per day using wet chemistry methods. Tanks were held between 20–50 ppm of chlorine. Logs indicated that both chiller tanks were held between 44–48 ppm on May 9, 2011 to May 11, 2011.

Observation of Work Practices

During our visit, we observed activities in each work area and employee PPE use. Footwear sanitizers containing quaternary ammonium compounds for work boots were located at the plant entryways. Eating food and chewing gum were permitted only in the break room and cafeteria; we did not observe employees doing either while in the work area.

During our visit, we noticed two water coolers in the live hang area (Figure 3). Live hang employees were permitted to leave the line briefly to drink water from these water coolers. We observed live hang employees obtaining water from these coolers without removing their PPE, including their gloves. This practice may be a potential source of exposure (i.e., ingestion) of *Campylobacter* bacteria.

We observed inconsistent hand washing procedures across many areas of the plant, especially at break times. Before entering the break room, some employees washed their aprons and gloves with

Figure 5. Hand washing station in the plant. The soap dispenser required the employee to push the lever to release the soap.

Figure 6. Deposit bin for PPE used by live hang employees at the time of our visit.

soap, then removed this PPE, but did not wash their hands. Other employees washed their hands and then removed and rinsed their unwashed apron. Also, while most of the hand washing stations had hands-free sink operations, most of the soap dispensers and waste receptacles were not hands-free (Figures 4 and 5). Thus, these surfaces may become contaminated with *Campylobacter* bacteria or other infectious organisms and pose another source of exposure.

We observed inconsistent and suboptimal use and removal of PPE within the plant. For example, not all live hang employees wore safety glasses as required. We also observed some live hang employees wearing smocks in the break room. Also, though N95 filtering facepiece respirators were not required in the receiving/live hang area, we observed some employees wearing them incorrectly.

Liver/gizzard inspectors, drawer/venters in the evisceration area, and dapec/rehang employees were not required to wear gloves because they could become caught in the machinery and cause injury. We observed that all of the liver/gizzard inspectors and most of the rehangers did not wear gloves.

At the time of our visit, the new live hang area was open and operating, but the new locker room and break room were not yet open. Because of this, at the beginning of breaks, we observed live hang employees removing their PPE as they exited the area, walking approximately 25 yards outside and around the corner, and depositing their PPE in the marked bins (Figure 6). This configuration may increase the potential for cross-contamination.

Though the new locker room and break room adjacent to the live hang area were not open and operating, we did tour this part of the plant during our visit. This area contained hand washing stations featuring air hand dryers, a small shower facility, lockers for personal effects, and a small dining area with tables and vending machines. The opening of this new locker room and break room should facilitate the disposal of used PPE if bins are placed in this area.

Review of Confirmed *Campylobacter* Infection Cases

Between January 2008 and May 2011, 29 cases of laboratory-confirmed *Campylobacter* infection in individuals employed at the poultry processing plant were identified by the Virginia Department of Health and the Virginia Department of

Corrections. Of these, 23 had diagnoses of *Campylobacter jejuni*, 1 had a diagnosis of *Campylobacter coli*, 4 had diagnoses of unspecified *Campylobacter* species, and 1 was an unknown species. Twenty-seven cases were diagnosed by stool culture; 2 were diagnosed by stool EIA. None were diagnosed with Guillain-Barre syndrome. A graph displaying the number of these confirmed cases by month of symptom onset is shown in Figure 7.

The median age of the 29 cases was 29 years with a range of 19–52 years. Twenty-eight of these were male; one was female. A total of 23 cases were residents of Diversion Center A, 3 cases were residents of Diversion Center B, and 3 cases lived at a private residence.

Of the 29 cases, 18 (62%) worked in the live hang area, 8 (28%) in the evisceration area, 1 (3%) in the kill room, 1 (3%) in the rehang area, and 1 (3%) in the cut-up area. The median amount of time worked at the plant before illness onset was 11 days, with a range of 3 days–865 days. Twenty-four (83%) cases worked at the plant for fewer than 30 days before illness onset.

Medical records from the Virginia Department of Corrections and other medical care providers were obtained for 24 employee cases. Three cases were reported to have been seen in the plant medical office. One case was hospitalized, and there were no deaths. All 24 cases were reported to have diarrhea. Other symptoms recorded included abdominal cramping (n = 14), fever (n = 9), nausea (n = 6), headache (n = 7), vomiting (n = 6), and muscle aches (n = 3). Seventeen cases were treated with antibiotics for their infection.

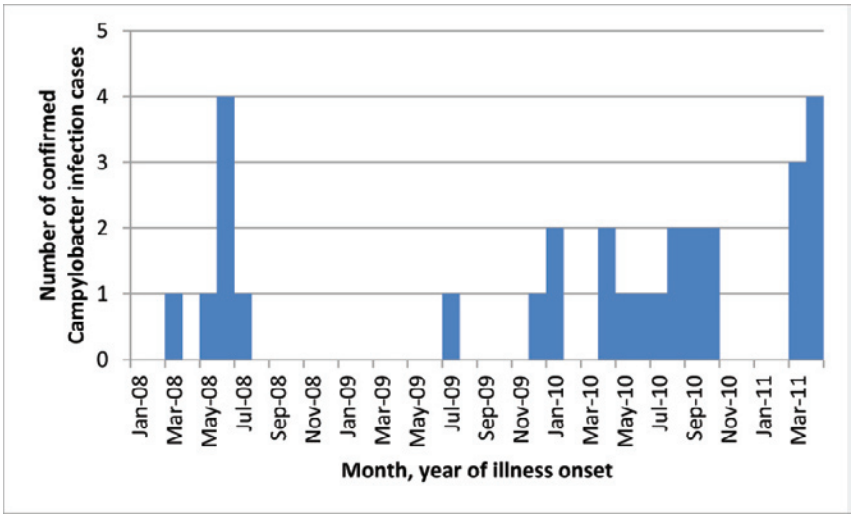


Figure 7. Number of confirmed *Campylobacter* infections in employees at the poultry processing plant by month of illness onset.

Discussion

Our investigation revealed 29 cases of laboratory-confirmed *Campylobacter* infection in individuals employed at the poultry processing plant during the 3½-year period from January 2008 to May 2011. Most of these individuals worked in the live hang and evisceration areas, which are areas of higher contamination [Keener et al. 2004]. All but three individuals were residents of a diversion center. Most (83%) had worked at the plant for fewer than 30 days before illness onset.

These findings of illness in relatively new employees are similar to those from previous investigations of poultry processing workers [Christenson et al. 1983; Cawthraw et al. 2000]. An outbreak investigation by Christenson et al. of *Campylobacter* infection among poultry abattoir workers in Sweden revealed that attack rates of infection were higher in inexperienced teenage holiday workers than in the experienced staff [Christenson et al. 1983]. Similarly, an investigation by Cawthraw et al. found that long-term workers (> 1 month) in Sweden had significantly higher levels of anti-*Campylobacter* antibodies compared to short-term workers (≤1 month) and compared to blood donors with no special exposure to poultry. Those findings indicated that poultry workers are at most risk of developing *Campylobacter* infection in their first weeks of working and then develop immunity that may be protective against future symptomatic infection [Cawthraw et al. 2000].

While there were 29 confirmed cases of *Campylobacter* infection, our interviews and review of the plant medical office records revealed that gastrointestinal illness was quite common. We found that approximately 15% of the more than 3,000 encounters at the plant's medical office from January 2010 through September 2011 were related to gastrointestinal symptoms. In addition, 28 (32%) of 88 interviewed employees reported being ill with gastrointestinal symptoms between January–May 2011. As with the employees with confirmed infection, most interviewed employees reporting illness reported that symptoms occurred within the first month of working at the plant. Most of these ill employees worked in the live hang area, but others worked in the rehang, evisceration, deboning, and stack-off areas.

We found that most (62%) of the 29 confirmed cases of *Campylobacter* infection occurred in live hang employees. Only approximately 50 employees out of the 1,000 person workforce work in the live hang area, suggesting that employees in this area are disproportionately affected. Similarly, in our interviews, we found that 34% of the 56 employees who worked in the receiving/live hang area reported a gastrointestinal illness in the preceding 5 months. The receiving/live hang areas were known to be areas of high contamination with *Campylobacter*, as the

feathers, skin, crop, cloaca, and feces of birds brought to slaughter are often highly contaminated with *Campylobacter* [Berrang and Dickens 2000]. Transport cages are important sources of cross-contamination [Berrang et al. 2003], and the presence of *Campylobacter* on birds at receiving has been linked to dirty cages [Slader et al. 2002].

The high number of *Campylobacter* infections that was observed in live hang employees suggests that preharvest practices in use by the plant and hatcheries may not be sufficient to control *Campylobacter* contamination on live birds. USDA has noted that high levels of *Campylobacter* loads on live birds can undermine other in-plant interventions [USDA 2010].

According to plant records, 15 (3%) of 451 carcass wash samples collected from second processing were found to have *Campylobacter* contamination over the 5 months prior to our site visit. This suggests that second processing employees had some risk of *Campylobacter* exposure. However, chlorine levels in the water immersion chillers, as reported on the company log sheets, were within USDA requirements [USDA 2010].

In the live hang area, airflow originating from the supply ducts above the employees' heads was directed from both sides of the live hang conveyor and may have aerosolized or spread potential contamination from the birds to the live hang employees. This is of concern because it has been suggested that *Campylobacter* exposure may occur through both airborne and droplet aerosol transmission [Wilson 2004]. It is also of concern because it may increase live hang employees' exposures to other contaminants on the chickens including organic dusts, nuisance dust particles, endotoxin, and other biological agents that have been identified as potential exposures in this environment [Lenhart and Olenchock 1984; Rylander 1984; Rees et al. 1998; OSHA 2011]. OSHA has provided some guidance on the design of ventilation controls in live hang areas indicating that make-up air should be provided behind the employee and exhausted from the far side of the conveyor [OSHA 2011]. However, because live hang employees worked on both sides of the conveyor at this plant, this would not be effective in reducing potential bioaerosol exposures among live hang employees. Alternative ventilation system design strategies are provided in the recommendations section.

In the live hang area, the water coolers inside the area posed a potential for cross-contamination, as employees left the line to

obtain water without washing their hands or removing PPE. In addition, we observed inconsistent hand hygiene and PPE use in the live hang area, and these observations corroborated the self-reported practices of interviewed employees. In addition to exploring methods to reduce contamination of incoming birds, efforts to educate receiving and live hang area employees about their risk of *Campylobacter* infection and the importance of hand hygiene and PPE use should be strengthened.

Plant policy required employees to report illnesses, yet fewer than half of the employees who reported illness during our interviews stated that they saw a plant healthcare provider for their illness. In addition, almost one third of employees reporting illness stated that they did not see any healthcare provider for their illness. Thus, illness appears to be underreported among employees, and 29 cases are likely an underestimation of the actual number of cases of *Campylobacter* infection among employees. The lack of paid sick leave may play a role in this lack of reporting and suggests a need to re-examine this policy.

Our HHE was subject to some limitations. First, because of the large number of employees at the plant, it was not possible for us to interview all of them during our visit. As a result, we limited the interviews to all first and second shift employees in the receiving/live hang areas, all employees residing at diversion centers, and a convenience sample of employees from other locations. We also were not able to characterize the employees seeking medical care from the plant medical office by work area. Thus, we were unable to capture the self-reported incidence of gastrointestinal illness across most of the other areas of the plant. However, our analysis of the confirmed cases of *Campylobacter* infection demonstrates that the attack rate appears to be highest among the receiving/live hang employees. Also, the likelihood of selection bias that occurred with the interviews prevented us from making any comparisons between those employees who reported illness and those who did not as we specifically focused on receiving employees and other employees who were also residents of diversion centers. In addition, our interview findings may have been subject to recall bias, as employees were asked to recall events of the previous 5½ months.

Conclusions

A health hazard from *Campylobacter* infection existed in this plant. Most confirmed cases of infection occurred in employees in the live hang area, those who were also residents of a diversion center, and those who worked at the plant for less than a month before illness onset. Our interviews and review of the plant medical office records revealed that gastrointestinal illness was quite common but appears to be underreported.

Recommendations

On the basis of our findings, we recommend the actions listed below to decrease the incidence of *Campylobacter* infection and create a more healthful workplace. We encourage the poultry processing plant to use a labor-management health and safety committee or working group to discuss the recommendations in this report and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the plant. Our recommendations are based on the hierarchy of controls approach. This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. If they are not effective or feasible, administrative measures and/or PPE may be needed.

Comprehensive recommendations and best practices for controlling *Campylobacter* throughout the entire cycle in poultry processing plants can be found in the USDA FSIS "Compliance Guideline for Controlling *Salmonella* and *Campylobacter* in Poultry" at http://www.fsis.usda.gov/PDF/Compliance_Guide_Controling_Salmonella_Campylobacter_Poultry_0510.pdf [USDA2010]. The primary purpose of these recommendations, however, is to increase food safety for consumers, not necessarily to protect the health and safety of employees at poultry processing plants. Although these recommendations have implications for protecting the health of employees, additional measures are needed to improve this protection.

Engineering Controls

Engineering controls reduce exposures to employees by removing the hazard from the process or placing a barrier between the hazard and the employee. Engineering controls are very effective at protecting employees without placing primary responsibility of implementation on the employee.

1. Install hands-free soap dispensers and hands-free waste receptacles at all hand washing stations to minimize employee contact with surfaces that may be contaminated with *Campylobacter* bacteria or other infectious organisms.

2. Move the two water coolers from the live hang area to help limit contamination of drinking water with poultry matter. Consider placing the coolers in a covered/shaded area outside the live hang area, or in the adjacent locker room/break room. Consider providing hands-free water dispensers.

3. Sanitize and dry transport cages thoroughly as recommended by the USDA FSIS [USDA 2010]. Research suggests that a two-step process that first cleans and disinfects cages is effective in reducing bacterial burden [Ramesh et al. 2004].

4. Modify the supply vents in the live hang area to redirect airflow vertically downward from above the employees' heads toward the floor and away from the live hang conveyor. This may help to reduce aerosolization of contaminants on the conveyor and also provide an air shower to help reduce inhalation of contaminants. If adjustments to the supply air ducts cause eye irritation or dry eyes, require employees to wear face shields or goggles.

5. Other strategies that could be used to reduce airborne contaminants in the live hang area include the following:
    - Reposition supply air ducts away from the employees and conveyors.
    - Add local exhaust ventilation near the conveyor to capture contaminants near the chickens. Consult a ventilation engineer familiar with poultry processing plants for specific designs.

- Wet down birds before they are shackled [Ortiz et al. 1990]. This may reduce aerosolization of contaminants on birds but may make the chickens harder to grasp.

Administrative Controls

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to workplace hazards. The effectiveness of administrative changes in work practices for controlling workplace hazards is dependent on management commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production.

1. Provide detailed training to all employees upon hire and at least annually thereafter on when and how to wash their hands. Employees should wash their hands before and after work; after contact with chickens or related products; before eating, drinking, or smoking; and before putting on and after removing PPE including gloves. Consider placing copies of the signs found in the Appendix, illustrating proper technique, above all hand washing stations throughout the plant. Supervisors and managers should periodically observe hand washing procedures and provide re-education on proper technique as necessary. The Centers for Disease Control and Prevention recommends washing hands with soap and water for 20 seconds. Additional information on hand hygiene can be found at http://www.cdc.gov/handwashing/.

2. Continue to offer all training to employees in English and Spanish to ensure employee comprehension.

3. Recommend that employees change clothes before going home from work to prevent cross-contamination of vehicles and homes and potential secondary exposure and infection of household members.

4. Train medical staff at the plant to recognize and inquire about diarrheal illness in employees, make appropriate recommendations to seek additional healthcare, and encourage employees to stay home while ill.

5. Examine the plant's sick leave policy for employees and make changes to ensure that employees do not work when ill. Consider a paid sick leave policy.

6. Work closely with diversion center medical staff and health district staff to ensure that all cases of diarrheal illness are reported as appropriate.

7. Continue to work with growers and veterinary staff to explore on-farm strategies to reduce the incidence rates of poultry contamination. Sound management practices incorporate good husbandry and hygiene practices. The USDA FSIS guidelines include preharvest strategies designed to lower *Campylobacter* contamination among incoming birds [USDA 2010].

Personal Protective Equipment

PPE is the least effective means for controlling employee exposures. Proper use of PPE requires a comprehensive program, and calls for a high level of employee involvement and commitment to be effective. The use of PPE requires the choice of the appropriate equipment to reduce the hazard and the development of supporting programs such as training. PPE should not be relied upon as the sole method for limiting employee exposures.

1. Provide training to all employees on proper use of required and recommended PPE specific to their job as defined in the OSHA PPE general requirements standard [29 CFR 1910.132]. Training should include how to put on, wear, and remove each PPE component and should include indications for cleaning or changing out PPE and how to dispose of used PPE. This training should be provided and documented on hire and at least annually thereafter. Retraining is also necessary when (1) changes in the workplace or types of PPE used render previous PPE training obsolete and when (2) employees are observed using PPE incorrectly. It is important to note that the OSHA respiratory protection standard [29 CFR 1910.134] and electrical protective equipment standard [29 CFR 1910.137], when applicable, have different training requirements that supersede those noted above.

2. Provide PPE at no cost to employees as defined in the OSHA PPE general requirements standard [29 CFR 1910.132]. This standard states that the employer is not required to pay for non-specialty safety-toe protective footwear (including steel-toe shoes or steel-toe boots) and non-specialty prescription safety eyewear, provided that the employer permits such items to be worn off the job site. In addition, the employer is not required to pay for everyday clothing. However, the employer must pay for replacement PPE, except when the employee has lost or intentionally damaged the PPE.

3. Ensure that line leaders, supervisors, and managers are familiar with the required PPE for their areas and encourage them to enforce its use among employees.

4. Encourage all employees to use the footwear sanitizers upon entry and exit from the plant floor.

5. Define when voluntary use of respirators by employees is permitted. Follow the OSHA respiratory protection standard [29 CFR 1910.134] regarding voluntary use, including providing a copy of Appendix D of the OSHA respiratory protection standard [29 CFR 1910.134] to employees.

6. Consider making the use of face shields mandatory in the live hang area to help limit employee exposure to poultry materials likely contaminated with zoonotic pathogens such as *Campylobacter*. Face shields provide additional protection over goggles or safety glasses by helping to prevent oral exposure. The use of respiratory protection against both infectious agents as well as dust from feathers, litter, and fecal matter should be considered in accordance with the OSHA respiratory protection standard [29 CFR 1910.134].

REFERENCES

Altekruse SF, Stern NJ, Fields PI, Swerdlow DL [1999]. *Campylobacter jejuni*—an emerging foodborne pathogen. Emerg Infect Dis *5*(1):28–35.

ASHRAE [2010]. American Society of Heating, Refrigerating, and Air-Conditioning Engineers Handbook – Refrigeration. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., p. 31.8.

Berrang ME, Dickens JA [2000]. Presence and level *of Campylobacter spp*. on broiler carcasses throughout the processing plant. J Appl Poult Res *9*(1):43–47.

Berrang ME, Northcutt JK, Fletcher DL, Cox NA [2003]. Role of dump cage fecal contamination in the transfer of *Campylobacter* to carcasses of previously negative broilers. J Appl Poult Res *12*(2):190–195.

Blaser M [1997]. Epidemiologic and clinical features of *Campylobacter jejuni* infection. J Infect Dis *176*(suppl 2):S103–105.

Cawthraw SA, Lind L, Kaijser B, Newell DG [2000]. Antibodies, directed towards *Campylobacter jejuni* antigens, in sera from poultry abattoir workers. Clin Exp Immunol *122*(1):55–60.

Christenson B, Ringner A, Blucher C, Billaudelle H, Gundtoft KN, Eriksson G, Böttiger M [1983]. An outbreak of *Campylobacter* enteritis among staff of a poultry abattoir in Sweden. Scand J Infect Dis *15*(2):167–172.

CDC (Centers for Disease Control and Prevention) [2011a]. Questions & Answers: Guillain-Barré Syndrome (GBS). [http://www.cdc.gov/flu/protect/vaccine/guillainbarre.htm]. Date accessed: November 2011.

CDC [2011b]. Vital signs: incidence and trends of infection with pathogens transmitted commonly through food — Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 1996–2010. MMWR *60*(22):749–755.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

References

Friedman CR, Neimann J, Wegener HC, Tauxe RV [2000]. Epidemiology of *Campylobacter jejuni* infections in the United States and other industrialized nations. In: Nachamkin I, Blaser MJ, eds. Campylobacter. 2nd ed. Washington, DC: American Society for Microbiology Press. pp. 121–138.

Harris NV, Weiss NS, Nolan CM [1986]. The role of poultry and meats in the etiology of *Campylobacter jejuni/coli* enteritis. Am J Public Health *76*(4):407–411.

Hopkins FS, Olmsted R, Istre GR [1984]. Endemic *Campylobacter jejuni* infection in Colorado: identified risk factors. Am J Public Health *74*(3):249–250.

Kapperud G, Skjerve E, Bean NH, Ostroff SM, Lassen J [1992]. Risk factors for sporadic *Campylobacter* infections: results of a case-control study in southeastern Norway. J Clin Microbiol *30*(12):3117–3121.

Keener DM, Bashor MP, Curtis PA, Sheldon BW, Kathariou S [2004]. Comprehensive review of *Campylobacter* and poultry processing. Compr Rev Food Sci Food Safety *3*(2):105–116.

Korlath JA, Osterholm MT, Judy LA, Forfang JC, Robinson RA [1985]. A point-source outbreak of campylobacteriosis associated with consumption of raw milk. J Infect Dis *152*(3):592–596.

Lenhart SW, Olenchock SA [1984]. Sources of respiratory insult in the poultry processing industry. Am J Ind Med *6*(2):89–96.

McCrea BA, Macklin KS, Norton RA, Hess JB, Bilgili SF [2006a]. A longitudinal study of *salmonella* and *Campylobacter jejuni* isolates from day of hatch through processing by automated ribotyping. J Foot Prot *69*(12):2904–2914.

McCrea BA, Tonooka KH, Van Worth C, Atwill ER, Schrader JS [2006b]. Colonizing capability of *Campylobacter jejuni* genotypes from low-prevalence avian species in broiler chickens. J Food Prot *69*(2):417–420.

Newell DG, Wagenaar JA [2000]. Poultry infections and their control at the farm level. In: Nachamkin I, Blaser MJ, editors. Campylobacter. 2nd ed. Washington, DC: ASM Press, pp. 497–510.

REFERENCES (CONTINUED)

Oosterom J, den Uyl CH, Banffer JR, Huisman J [1984]. Epidemiological investigations on *Campylobacter jejuni* in households with a primary infection. J Hyg *93*(2):325–332.

Ortiz DJ, Jacobs DE, Courtney TK, Dunn J, Wyvill JC, Smith KA, Braza K, Pettet T, Rentz P [1990]. A safety and health assessment of two chicken processing plants. [http://www.oshainfo.gatech.edu/nbc-rpt.pdf]. Date accessed: January 2012.

OSHA [2011]. Poultry processing industry e-tool. [http://www.osha.gov/SLTC/etools/poultry/receiving/03_live_hang.html]. Date accessed: January 2012.

Ramesh N, Joseph SW, Carr LE, Douglass LW, Wheaton SB [2004]. A prototype poultry transport container decontamination system: II. Evaluation of cleaning and disinfecting efficiency. Am Soc Agri Eng *47*(2):549–556.

Rees D, Nelson G, Kielkowski D, Wasserfall C, da Costa A [1998]. Respiratory health and immunological profile of poultry workers. S Afr Med J *88*(9):1110–1117.

Rylander R. [1984]. Lung reactions during poultry handling related to dust and bacterial endotoxin levels. Eur J Respir Dis *65*(40):266–271.

Skirrow MB [1982]. *Campylobacter* enteritis—the first five years. J Hyg *89*(2):175–184.

Slader J, Domingue G, Jorgensen F, McAlpine K, Owen RJ, Bolton FJ, Humphrey TJ [2002]. Impact of transport crate reuse and of catching and processing on *Campylobacter* and *Salmonella* contamination of broiler chickens. Appl Environ Microbiol *68*(2):713–719.

Tauxe RV, Deming MS, Blake PA [1985]. *Campylobacter jejuni* infections on college campuses: a national survey. Am J Public Health *75*(6):659–660.

USDA (U.S. Department of Agriculture) [1996]. Pathogen reduction; hazard analysis and critical control point (HACCP) systems. FSIS final rule. 61 FR 38806. Washington, DC: U.S. Government Printing Office.

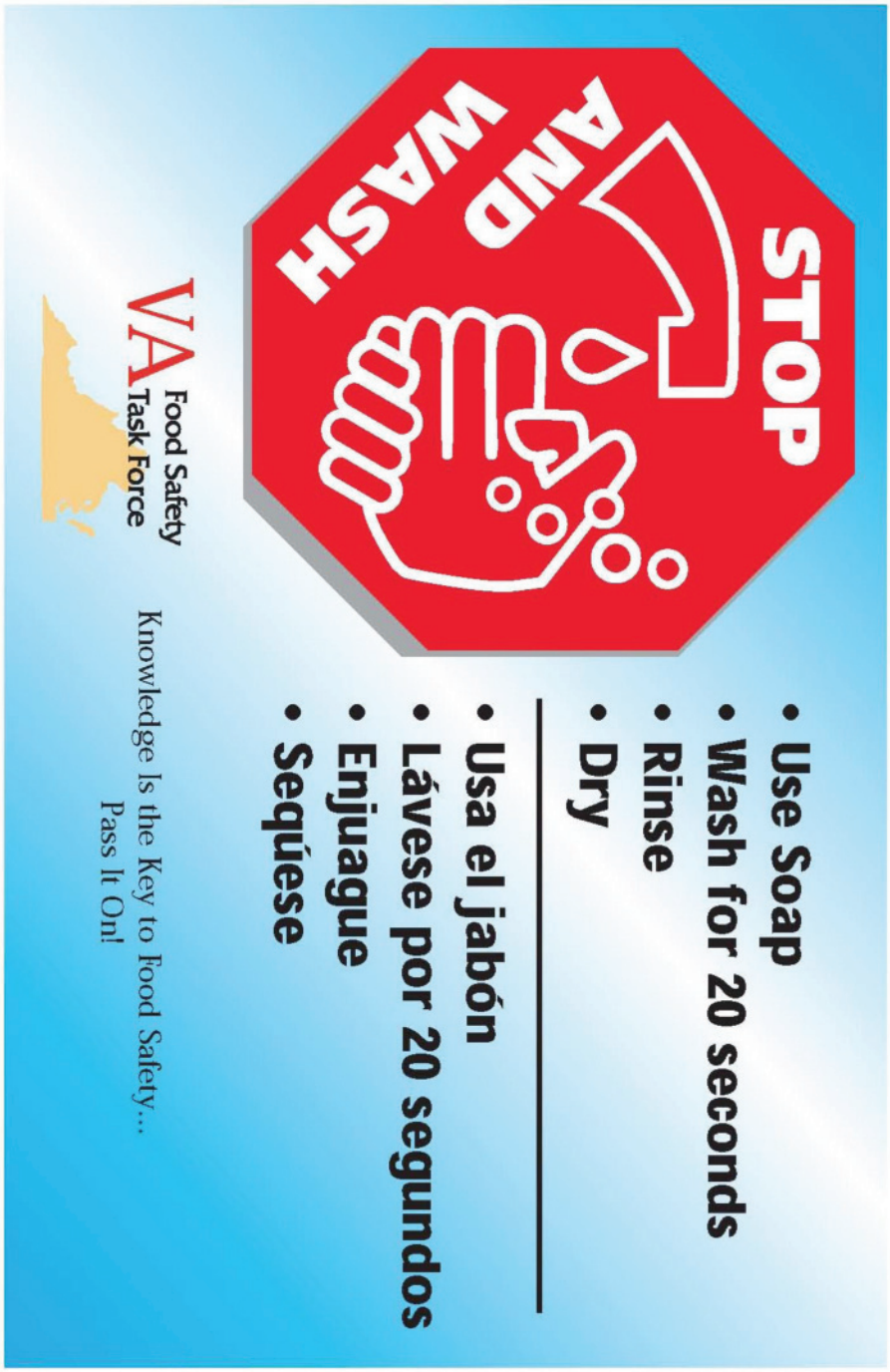
REFERENCES (CONTINUED)

USDA [2010]. Compliance guidelines for controlling *Salmonella* and *Campylobacter* in poultry, 3rd ed. [http://www.fsis.usda.gov/PDF/Compliance_Guide_Controling_Salmonella_Campylobacter_Poultry_0510.pdf]. Date accessed: December 2011.

Wilson IG [2004]. Airborne *Campylobacter* infection in a poultry worker: case report and review of the literature. Commun Dis Public Health 7(4):349–353.

Appendix: Hand Hygiene Signs

The two signs on the next two pages present proper hand washing technique in English and Spanish.



Appendix: Hand Hygiene Signs (continued)

Acknowledgments and Availability of Report

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Copies of this report have been sent to employee and management representatives at the poultry processing plant, the state health department, and the Occupational Safety and Health Administration Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed at http://www.cdc.gov/niosh/hhe/. Copies may be purchased from the National Technical Information Service at 5825 Port Royal Road, Springfield, Virginia 22161.

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